PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Turbine Assembly Including an Emergency Brake System

We, THE BENDIX CORPORATION, formerly known as Bendix Aviation Corporation, a corporation of the State of Delaware, United States of America, of Fisher Building, Detroit, Michigan, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a turbine assembly having a gas-driven high speed turbine wheel and more particularly to a turbine assembly designed for use as a power device namely in aircraft engine starters.

When a turbine assembly is incorporated in aircraft engine starters, there have been instances of failure of the governing device which maintains a safe relation between the impulse force of the turbine wheel and the load being driven. The governor normally prevents excessive speed of the turbine when under no load. For example, in a turbine starter which is powered by combustion gases, the governor is actuated at a predetermined speed (about 44,000 RPM) to interrupt the flow of fuel and air to the combustion chamber. If the governor fails to so operate, with the starter under no load after start-up, the turbine wheel can rapidly attain what is commonly known as a "runaway" condition. In extreme cases of this condition, when the stresses induced in the turbine wheel by high rotational speeds exceed the strength of material, a disintegration of the turbine wheel results which is characterized by the ejection at high speeds of the blades of the turbine wheel and sometimes wheel throw-out. This extremely dangerous condition is, of course destructive of equipment and hazardous to nearby personnel.

The primary object of the present invention is to prevent the aforenoted hazard by providing improved means which senses a condition of extreme speed and then imposes a restraining force on the turbine wheel whereby a disintegrating speed is prevented.

A further object is the provision of emergency braking means which mechanically senses extreme speed and then applies a braking action against the side of the turbine wheel.

According to the invention there is provided a turbine assembly having a turbine wheel and wherein an emergency braking system is provided for braking the latter when it is rotated at excessive speed, said braking system including brake means engageable with the turbine wheel for braking the same, means normally retaining the brake means away from said turbine wheel, means carried by the turbine wheel for rendering the retaining means ineffective when the turbine wheel is rotated at excessive speed, and a spring device arranged to urge the brake means against the turbine wheel when the retaining means is ineffective.

The invention will now be described by way of example with reference to the accompanying drawings in which:—

Figure 1 is a longitudinal cross-sectional view of the turbine section of a turbine starter embodying the invention; and

Figure 2 is a transverse cross-sectional view along the line 2—2 of Figure 1 and shows the centrifugally-actuated cutting mechanism for releasing the mechanical brake shown at the right hand side of the turbine wheel in Figure 1.

In Figure 1, it can be seen that an axial flow impulse type turbine wheel 11 having peripheral blades 13 and an integral shaft 14 is mounted by its shaft in bearings 15. The bearings have a diagrammatically-illustrated annular seal 17 and are supported by a transverse housing wall 19. One brake device is mounted at each side of the turbine wheel 11 and will be described hereinafter.

Combustion gases from the combustion

[*Price 3s. 6d.*]

Price 4s 6d

chamber (not shown) are directed against the turbine buckets or blades 13 by nozzles 21 which are mounted in an annular nozzle ring 23. The nozzle ring 23 has attached thereto a concave circular wall 25 of the combustion chamber whereby transverse wall means are formed at the side of the turbine wheel which is opposite the turbine shaft and mounting. The gases which drive the turbine and leave the turbine blades 13 are deflected by an annular heat insulating shield 26 towards an exhaust shroud 27. An annular exhaust chamber is formed by shield 26, exhaust shroud 27 and nozzle ring 23. The gases are discharged through an exhaust shroud port which is not shown. It is to be noted that the heat shield 26 is clamped between the exhaust shroud 27 and the transverse housing wall 19 and is attached at its radially inner edge to an annular bearing retainer 28 which is threaded on an axial tubular extension 29 of the housing wall 19. A radially inwardly-extending flange 31 of the retainer 28 retains the bearing seal 17. The turbine shaft 14 is connected by splines to a member of the initial stage of reduction gearing (not shown). The reduction gearing is operably connected through conventional means (not shown) to an aircraft turbine engine so that the high speed starter turbine can bring the aircraft turbine engine up to starting speed. At this speed, combustion gases and the starter jaw disengages. The combustion gases are provided by an air bottle and a fuel tank (not shown). It is to be noted that the combustion chamber wall 25, the nozzle ring 23, the exhaust shroud 27, the housing wall 19 and the arrangement for mounting the turbine wheel only at one side, provide a compact turbine section in an engine starter.

The stainless steel turbine wheel 11 of wedge-shaped cross-section has axially mounted thereon, at its right hand side, an assembly which consists essentially of a carrier structure and two centrifugally-actuated cutter blades 42 which function to release a brake shoe, hereinafter described. The carrier is attached to the turbine wheel by a screw 43 which threads into an axial extension 44 of the turbine wheel. The two cutter blades 42 are pivoted on two pins 45 which are mounted in recesses in the right hand face of the turbine wheel and in an opening in the right hand wall 46 of the carrier structure. This structure has another wall 48 abutting the other side of the cutter blades and the central face of the turbine wheel.

In Figure 2, certain features of the cutter assembly appear more clearly. It can be noted that the blades 42 which are pivotally mounted on pins 45 are restrained from centrifugal movement by shear pins 47. The two transverse washer-like walls 46,48 of carrier structure are connected by longitudinally-extending parts 49 of triangular cross section. It is to be noted that the cutter blades 42 will pivot outwardly about pivot pins 45 when a predetermined centrifugal force exists which is sufficient to shear the small shear pins 47. If for any reason one cutter blade is released before the other, a tang or short extension 50 of the blade (which is pivoted radially inwardly) will contact the other blade and exert additional force for the shearing of the remaining shear pin 47. The total travel of the cutter blades 42 is controlled by the travel of the radially inner and curved part of the tang 50 since it will contact the axial extension or pilot stub 44 of the turbine wheel after a predetermined radially inward travel.

Referring again to Figure 1, it can be seen that the brake shoe structure 55 has a transversely-extending annular part or brake shoe 56 of stainless steel which has an inclined annular rubbing surface 57. This large surface is closely spaced to the adjacent complementary-inclined surface of the radially-intermediate part of the turbine wheel 11. The brake shoe structure 55 has as an integral part, a tubular axially-extending segment or part 54 which is constructed with a thin wall or reduced section 53 cut through by the blades 42 when the latter are rotated radially outwardly by centrifugal action. The right hand end of the tubular part 54 is attached by a flange to the concave combustion chamber wall 25 by means of a lock nut 58 threaded on to an axial tubular extension 59 which is welded to the combustion wall 25. Shims 60 are provided to adjust the clearance between the inclined surface of the turbine wheel and the brake shoe surface 57. The shims 60 allow for positioning so as to provide for normal heat distortion of the component parts without developing contact.

The brake assembly additionally includes a pack of annular clutch-type energy absorbing discs 63 and an arrangement of compressed Belleville springs 64 to provide the axial braking force. The clutch discs are alternated with annular washer-like rings of dissimilar material, such as a chrome-plated stainless steel and an oxidized nickel-chrome alloy. These discs 63 are confined between the brake shoe 56 and an annular washer-like ring or static back-up plate 65. The outer most part of the washer-like ring 65 has welded thereto, on the left hand side, an annular positioning and guide ring 66 which has a plurality of equi-spaced teeth 67 fitted into corresponding closely-fitting longitudinal grooves 68 in the nozzle ring 23. Guide ring 66 encases the discs 63 and also abuts the outermost part of the right hand surface of the brake shoe 56. The Belleville springs 64 are compressed against washer-like ring 65 by means of washer

71 and snap ring 72 which fits into a groove in the tubular extension 54 of the brake shoe structure 55. It is apparent that, when the cutter blades 42 are pivoted outwardly a pre-determined distance which is just sufficient to sever the reduced section 53, the Belleville springs 64 will urge the stainless steel brake shoe 56 into contact with the side of the turbine and that the axial movement will be guided by the teeth 67 sliding in the recesses or grooves 68. Furthermore, the tabs or teeth 67 also prevent rotation of the back-up plate 65 so that the braking action is augmented.

At the inclined side surface of the turbine wheel 11 which is adjacent its mounting, there is a substantially-axially-fixed brake assembly which is comprised of a stainless steel brake shoe 75, a disc pack 76 and a preloaded Belleville spring 77. These components of the back-up brake mechanism are held in position by a snap ring which is mounted in a groove in retainer 28 and are mounted on the member 28 which is threaded on the axial extension 29 of the housing wall 19. It is to be noted that the smaller brake shoe 75 also has an inclined surface which complements the adjacent or closely spaced inclined surface of the turbine wheel. The Belleville spring 77 bears against a radially outwardly-extending flange 78 which is an integral part of the annular bearing retainer 28 and against a washer 79 which abuts the disc pack 76. The annular stainless steel brake shoe 75 together with the previously described axially-movable brake shoe 56 provide means for confining or restraining the turbine wheel in the event the turbine wheel shaft is broken adjacent the turbine due to the malfunctioning of the parts which it drives or of the bearings on which it is mounted. Braking by shoe 56 in extreme cases may adversely affect the bearings. Upon the turbine shaft being broken after the brake assembly 55 has come into action, the brake shoe 56 presses against the turbine wheel and moves it axially against the brake shoe 75. The disc pack 76, which is also comprised of stainless steel and oxidised-nickel-chrome alloy discs stacked alternately in series, permits rotation of the brake shoe 75 and provides large surface areas for the absorption of heat. The two brake assemblies located on opposite sides of the turbine thus operate in conjunction to reduce the speed thereof and to confine the turbine wheel between them. It is to be noted that with both disc packs 63, 76 the rubbing velocity of each disc sequentially from the rotating brake shoes to the static washer-like members is gradually less.

In operation, the centrifugal force developed by the cutter blades 42 at a predetermined speed (about 55,000 RPM) is sufficient to shear the restraining pins 47 and to cause the cutter blades to swing out on their respective pivot pins 45. This action occurs when the governing device fails and the turbine wheel is started toward "runaway" speed because the flow of the impulse-producing media has not been properly controlled by the governor. This lack of control can occur after the starter jaw is retracted or if the starter jaw does not engage the engine jaw during starting. When the blades 42 swing out, their extended pointed cutting edges contact and rapidly shear through the reduced section 53 of the brake shoe structure 55. This action permits the Belleville springs 64 to unload and force the severed brake shoe 56 against the side of rapidly-rotating turbine wheel 11. It is to be noted again that the total travel of the cutter blades is limited by means of their tangs 50 so that the wider part of the blades does not project between the ends of the severed reduced portion so far as to cause interference. When the turbine wheel rubs against the inclined surface 57 of the brake shoe 56, it is apparent that the large-surfaced disc pack 63 will also absorb heat energy and that there will be an incremental lower velocity of each disc sequentially from the turbine wheel toward the static back-up ring 65. In tests, the brake shoe 56 stopped the turbine without damage to the turbine shaft or combustion chamber wall. Only the brake assembly and the side of the turbine wheel were damaged. In the event, that the turbine wheel shaft is broken, brake 75 and disc pack 76 provide confinement and heat absorbing braking at the left hand side of the turbine.

From the foregoing, it is apparent that a turbine brake device has been provided which results in an essentially fail-safe condition, whereby turbine buckets or a turbine wheel are not thrown out through the housing. It is to be noted that the actuating mechanism having the cutting blades is directly connected to the turbine wheel and is centrifugally actuated so that the higher the speed of the turbine the greater the force generated to operate the cutter blades. Another noteworthy feature is the arrangement of the discs 63,76 which provides large-surfaced energy-absorbing members in addition to the brake shoe.

WHAT WE CLAIM IS:—

1. A turbine assembly having a turbine wheel and wherein an emergency braking system is provided for braking the latter when it is rotated at excessive speed, said braking system including brake means engageable with the turbine wheel for braking the same, means normally retaining the brake means away from said turbine wheel, means carried by the turbine wheel for rendering the retaining means ineffective when the turbine wheel is rotated at excessive speed, and a spring device arranged to urge the

brake means against the turbine wheel when the retaining means is ineffective.

2. A turbine assembly according to claim 1, wherein the brake means includes a brake shoe having a large rubbing surface uniformly spaced from one side of the turbine wheel and adapted to engage the same when the retaining means is rendered ineffective.

3. A turbine assembly according to claim 2, wherein the spring device urging the brake means against the turbine wheel includes a pack of energy absorbing plates confined between the brake shoe and a static back-up plate non-rotatably mounted in the turbine wheel housing and axially movable therein, and spring means compressed between said back-up plate and an element of the retaining means.

4. A turbine assembly according to claim 2, wherein the retaining means comprises a member which rigidly attaches the brake shoe to the turbine wheel housing and which includes a thin axially extending portion, and the means for rendering the retaining means ineffective comprises cutters carried by the turbine wheel and constructed and arranged to cut through the thin portion when the turbine wheel rotates at excessive speed.

5. A turbine assembly according to claim 4, wherein the cutters are constituted by centrifugally-actuated blades which are restrained by shear pins and are arranged for limited radially outward movement.

6. A turbine assembly according to claim 2, wherein a back-up brake assembly is provided at the side of the turbine wheel opposite the emergency braking system to restrain said wheel if it breaks away from its shaft, this assembly being carried by a rigid wall structure in which the turbine wheel is rotatably mounted.

7. A turbine assembly according to claim 6, wherein the back-up brake assembly includes a spring biased disc pack and a member having an inclined annular surface which is closely adjacent the side of the turbine wheel opposite the emergency braking system.

8. A turbine assembly substantially as described and as illustrated with reference to the accompanying drawings.

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872,654 COMPLETE SPECIFICATION
1 SHEET
This drawing is a reproduction of the Original on a reduced scale.

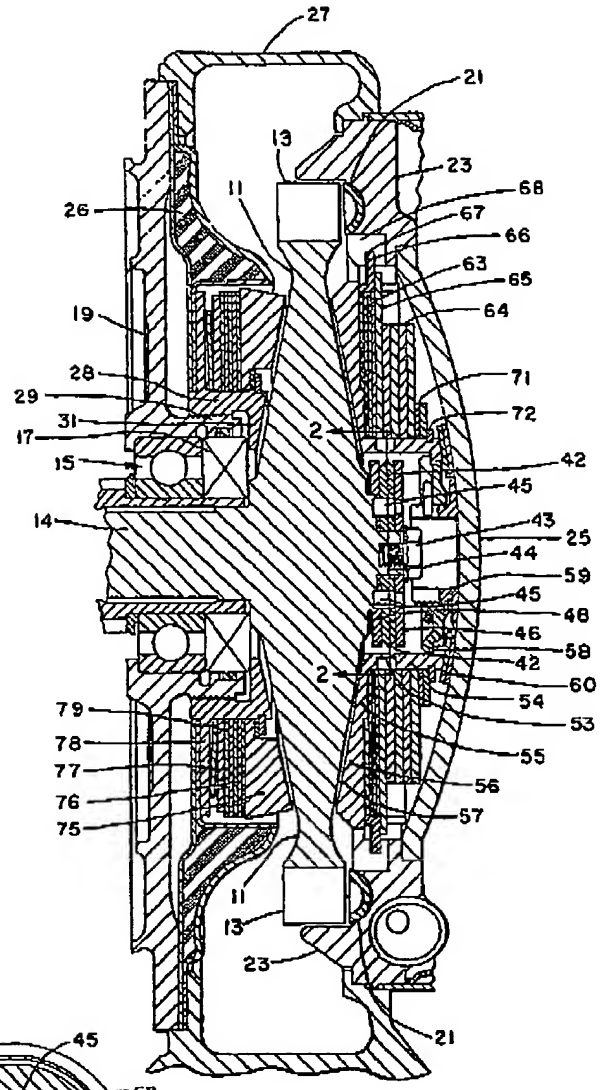

FIG. 1

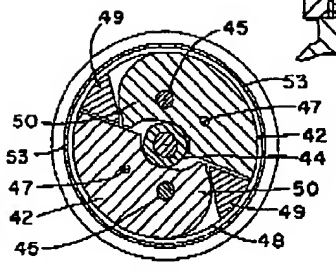

FIG. 2